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Impact of traditional community tanks rejuvenation on groundwater recharge and crop productivity in Yadgir district of Kalyan Karnataka Region, India

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ABSTRACT

Yadgir district is identified as most backward ditrict by NITI ayoga on account of their "lowest composite indicators in terms of health and nutrition, education, agriculture, water resources, financial inclusion, skill development and basic infrastructure. Traditional community tanks (TCT's) are classic examples of common pool resources that have been traditionally managed by local communities for irrigating their crops since age old and they are a living example that illustrates the capability of a man-made tank ecosystem evolved in harmony with nature to withstand natural disasters like drought, floods, and cyclones. These tanks not only protect and conserve the environment, but also contribute to livelihood security to rural farmers. These tanks have contributed significantly in agricultural production through supplementary irrigation and are declined recent decades in Yadgir district which is susceptible to drought compared to other district in the states. Such 13 TCT's were rejuvenated for enhancing water storage capacity in the district under *"Jal Samvardhane - District-wide Water Conservation Project" by* Bharatiya Jain Sangh (BJS) In colloboration with Dept. of Agriculture, Yadgir. The study proved that, the average water storage capacity was raised by 24.80 percent in selected rejunuvented TCT's. The average GWL increased for all selected tanks from 1.62 m to 3.81 m during the post-monsoon seasons of 2019 and 2020, respectively, compared to 1.31 metres before tank disiltation in Rabi 2018. Pigeonpea yield was increased by 4.13 percent (6.56 q/ha) to 20.57 percent (7.62 q/ha) with an average of 11.80 percent across all TCTs. Similarly, cotton prices increased by 4.85 percent (7.13 q/ha) to 21.53 percent (7.45 q/ha) throughout the growing season, with an average of 13.44 percent across all TCTs. Tank irrigation development activities have a substantial impact on groundwater recharge, access to groundwater, and in turn on the extension of irrigated water area. Tank irrigation development efforts have been shown to alter crop patterns, increase crop yields, and diversify crops, resulting in increased employment and farm income of small & marginal farmers of the Yadgir district.

Introduction

The total water available from precipitation in the country in a year is about 4,000 cubic km. The availability from surface water and replenishable groundwater is 1,869 cubic km and merely 60% of this can be utilized for advantageous purposes. Consequently, there are just 1,122 cubic km of

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usable water in the entire nation (Jain S K., 2019). The need of protecting and properly managing water resources has increased as Indian farmers struggle with the threat of groundwater depletion, weakening and irregular monsoons in recent years (Chowdhury and Behera, 2018). Traditional Community Tanks (TCTs), which are often built and maintained by villagers, are large reservoirs of water that have historically been used to irrigate more than 100 hectares of crops (Sathiyamoorthy et al., 2023; Reddy *et al.,* 2018). TCTs gather and store monsoonal rainwater in this traditional method of water harvesting, which is then used for drinking and protective irrigation during dry spells (Reddy and Behera, 2009). However, their use for irrigation has significantly decreased over the last few decades. TCTs were utilized to irrigate over 3.6 million hectares (17%) of the total irrigated land in India in 1950–1951, but in 2014–2015, that percentage had fallen to just 1.7 million hectares (2.5%) (Reddy *et al.,* 2018). Tank irrigation has always been given more weight in the southern and eastern regions, then in the west and north (Charles *et al.,* 2021). In reality, compared to other regions, the south had the greatest percentage of tanks in use in the nation, at 35% in 2000–01 (Anantha *et al.,* 2021b). Regionally, the area irrigated by tanks decreased steadily in both the south and the north from 1972 to 2008, with the exception of a small increase in the south from 2003 to 2008 (Anantha *et al.,* 2021a). The dramatic reduction in TCT irrigation over the previous decades was caused by a variety of factors, including institutional neglect, policy changes, population growth, and a shift to groundwater use (Singh *et al.,* 2022). Neglect combined with environmental degradation caused the tanks in drought-prone areas to silt, which lowered their capacity (Garg *et al.,* 2020). Populations were increasing at the same time, but the TCTs, which were only intended to serve a small population, nable to meet the needs of a growing population (Anuradha, 2014). After that, groundwater became more prevalent because to Geen revolution technologies and cheaper electricity (Garg *et al.,* 2020). This has resulted in private water management, while governmental policy has conveniently overlooked the upkeep of TCTs (Reddy *et al.,* 2018). TCTs are now deteriorated due to major reasons such as encroachment, siltation, soaking of supply channels, inadequate maintenance of bunds, lack of soil conservation, increase in tank -bed siltation and unauthorized cultivation. Due to this, well-irrigation gained traction and became the single greatest source of irrigation (Vico *et al.,* 2020). Wells began to dry up due to over-exploitation, and there has recently been a renaissance realizing the significance of these old systems (Everard *et al.,* 2018). However, efforts must be increased because less than 10% of decommissioned tanks have been rehabilitated in the last two decades (IGG 2020). In the face of climate change, a comprehensive water policy that encompasses tank irrigation as well as groundwater and canal irrigation and takes into account the variable quantities of rainfall expected in different regions is required (Garg *et al.,* 2020). This will make it easier to connect tanks to deal with extreme precipitation occurrences and connect tanks to canals to get prepared for dry spells (Brauns *et al.,* 2022). Tank capacity and number must be raised in areas that will receive short bursts of heavy rainfall (Stavi *et al.,* 2020). Natural resource management is the most important step toward sustainable development, and it necessitates a high level of participation from people who benefit directly and indirectly from that resource (Chinnasamy *et al.,* 2015). TCT management may be an useful way to conserve extra runoff generated during high rainfall events while also solving the present water crisis (Reddy *et al.,* 2018). Well irrigation and tank storage are inextricably linked, particularly in places with restricted aquifers and rock stratum 40-50 feet below ground (Singh *et al.,* 2022). TCTs assist recharge groundwater by holding runoff water for longer periods of time (Everard *et al.,* 2018). As a result, well owners are a key stakeholder group in tank systems; their interests collide with those of command area farmers (Malik *et al.,* 2014). In most places, the benefits of groundwater recharge have outweighed the benefits of direct irrigation from tanks (Deora and Nanore, 2019). This is reflected in increasing land values beyond the command area, which is regarded as the most valued benefit farmers obtain from the tanks (Srivastava *et al.,* 2008). This is mostly due to tank capacity drop, which has resulted in a reduction in command area (Reddy *et al.,* 2018). Indeed, groundwater irrigation in TCT commands is more dependable because to good recharge and is also available throughout the crop season (Chowdhury and Behera, 2018). Due to unstable water supply from tanks, most tail end farms rely on groundwater (Manjula, 2017). In Tamil Nadu, a U-shaped association between the number of private wells and tank degradation has been discovered (Bitterman *et al.,* 2016). The relationship between tank irrigation (surface water) and groundwater levels is found to be considerable in all conventional community tanks (Chowdhury and Behera, 2018). Tanks were shown to aid increase recharge by 40 % in Tamil Nadu (Van Meter *et al.,* 2016). It is believed that tank irrigation and well irrigation should be utilized in tandem rather than as alternatives to preserve hydrological balance and manage water resources responsibly in the long run (Pabba *et al.,* 2022). No rehabilitation programme in India has undertaken a full rehabilitation of the systems (Anuradha, 2014). The most comprehensive are those financed by the World Bank, whose works included strengthening earthen bunds, rebuilding completely broken sluices, restoring surplus weirs, rehabilitating supply and drainage channels, repairing canal structures, and selective lining of channels (Deora and Nanore, 2019). The impact assessment of rehabilitation programmes is also restricted to certain activities (IGG 2020). There have been very few research papers that have completely analysed the program's impacts in terms of cost-benefit analysis (Charles *et al.,* 2021). A few studies, however, have undertaken a cost-benefit analysis of a restricted number of tanks (Everard *et al.,* 2018). The improved availability of water, which is crucial for assessing the TCT's effectiveness, has been the subject of the impact research. Better water availability influences: irrigation area, cropping pattern, production rates, livestock, feed, employment, water distribution, and so on (Singh *et al.,* 2022). The NGO tank restoration experiments have also highlighted the livelihood aspects of tank dependent populations (Brauns *et al.,* 2022). However, few researches have evaluated the performance of TCTs in general or in relation to institutional arrangements (Biswas *et al.*, 2017). Though these studies did not analyse the impact of rehabilitation, they do provide insight into the potential impact of tanks when fully operational (Reddy and Behera, 2009). A number of studies have indicated significant improvements in productivity, crop intensity, employment, animal production, and so on; also, the supply of fuel wood has improved in the majority of the study tanks (Malik *et al.,* 2014). Another significant benefit of tank repair is improved groundwater recharge. Both drinking water and irrigation wells in the command area and beyond have benefited from rehabilitation (Anuradha, 2014). The increased recharge benefits landowning households directly while indirectly benefiting the poor and landless through an increase in employment days (Deivalatha, 2011). Water marketplaces have emerged, allowing even the destitute to gain access to water. Improved access to drinking water reduces the drudgery of women and children while also improving their quality of life. Simultaneously, extensive canal lining decreased groundwater recharge. In fact, the use of tank storage for artificial recharge during times of scarcity (using the tank as a percolation pond) is quickly gaining on in Karnataka, where orchards and cash crops are replacing grain crops and agricultural diversification is occurring under well irrigation (Brauns *et al.,* 2022). Lining could create a conflict of interest between well owners and command area farmers. Another significant area of influence and dispute is tank desilting, which is done in most NGO programmes but not in large donor-funded restoration programmes. Aside from increasing the tank's water storage capacity, applying tank silt to farmlands increases land production (Ali *et al.,* 2020). In a tank restoration project in AP, it was discovered that silt application enhances yield by 20 to 40% (Sharma *et al.,* 2015). It also lowered the consumption of chemical fertilizers by 50-60% compared to previous years. Tank desilting and application of tank silt to farm lands on a regular basis is a long-standing practice. Desilting is economically viable in Karnataka if there is a market for silt, according to estimates (Singh *et al.,* 2022). Carrying out desilting efforts has recently become tough, not for economic reasons, but due to a labour scarcity or lack of motivation to engage in such onerous work. Due to transportation costs, there aren't many buyers for silt. TCTs have been used for irrigation and residential purposes in Karnataka from ancient times. Though TCTs were a vital element of the agricultural production system, farmers began exploring groundwater through tube wells due to the lack of surface water in TCTs due to eratic and scattered rainfall between 1980 and 2000 (Brauns *et al.,* 2022). As a result, the majority of TCTs have been left unused and unrepaired by both the farming community and the government sector. Karnataka's Community Based Tank Management Project (KCBTMP) began in 2002 with the goal of rehabilitating 2000 irrigation tanks through community engagement on a trial basis. The Karnataka Government (GoK) established an autonomous agency named the Jala Samvardhane Yojana Sangha (JSYS) to manage the entire task (Reddy *et al.,* 2018). The project consisted of three parts: I creating an enabling environment for sustainable, decentralized tank management systems; ii) empowering community-based organizations to take up development and management operations; and iii) implementing system improvements. The goal is to repair the tanks and turn them over to tank user associations (TUAs). The project is supported by 57 cluster facilitation teams (NGOs). Despite having enormous land and water resources, Yadgir is regarded one of the most backward districts in the state and has been designated as an aspiration district. Agriculture in the area is primarily dependent on rainfall, with an average annual rainfall of 836 mm. The district is the most drought-prone in the state of Karnataka and has endured frequent droughts in recent years, causing considerable suffering to the agriculturally dependent society and increasing the vulnerability of the poor. Despite the fact that the district has 36 lift irrigation schemes and 445 minor irrigation tanks, the net area irrigated to net area seeded ratio is only 14 percent (Umesh Barikara, 2020). Groundwater levels in the district have been substantially reduced as a result of exploitation, natural discharge, and a lack of recharging during the pre-monsoon season. Water scarcity had an impact on home requirements, agriculture, livestock, and the livelihoods of the district farming population. As a result, in order to improve the district's water resources, NITI Ayoga chose Yadgir as one of the aspirational districts for a drought mitigation model under the "Jal Samvardhane-District-Wide Water Conservation Project," which was implemented by Bharatiya Jain Sangh (BJS) in collaboration with the Department of Agriculture, Yadgir, in 13 selected tanks during the first phase (Karnataka). As a result, the current study was done to investigate the impact of tank rejuvenation on water conservation and groundwater recharge, with the following goals in mind:

1. To study the effect of tank disiltation on water use, water storage capacity and groundwater recharge in study area.
2. To study the changes in major crop yield under selected community tank command area.

Material and Methods

Study area

The study on rejuvenation of tanks and its impacts were taken up in the selected villages of Yadgir in Kalyana Karnataka region of Karnataka state under "Jal Samvardhane -District-wide Water Conservation Project" by Bharatiya Jain Sangh (BJS) incolloboration with Dept of Agriculture, Yadgir (Fig.1). In first phase, district administration identified the 13 Traditional Community Tanks (TCT's) of various capacity and dimensions after doing the technical feasibility assessment among 350 tanks of the district for desilting works & simultaneously identified the point on *Nala* for construction of checkdams to stop runoff water. Planting of forest plant species which are suitable location were identified all around the bunds of 13 tanks to strengthen the bunds of selected tanks. The interlinking channel moved excess water from upstream to downstream tanks and final surplus flowed into the Bhima and Krishna rivers.

Rainfall data

The daily rainfall data for study period was collected from the near by meteorologica stations established by Central Ground Water Board & publi Works Department. The daily rainfall is estimated for monthly and annual rainfall and results are presented in Figure 2. The collected rainfall data was used to estimation of runoff, inflow and outflow to TCTs.

Details of selected traditional community tanks (TCT's)

The size of TCT's, volume of earth work incurred and number of farmers benefitted from each tanks is presented Table 1. Water storage capacity of selected tanks was calculated before & after the tank rejuvenation by knowing the volume of earth work incurred at each tank. Data on groundwater levels were measured using sensor-based groundwater level indicator at nearby observation wells. A field survey was conducted with beneficiaries under selected Traditional Community Tanks (TCT's) for collection of data related to major crops, cropping pattern, area under different crops before and after tank rejuvenation and used for calculation.

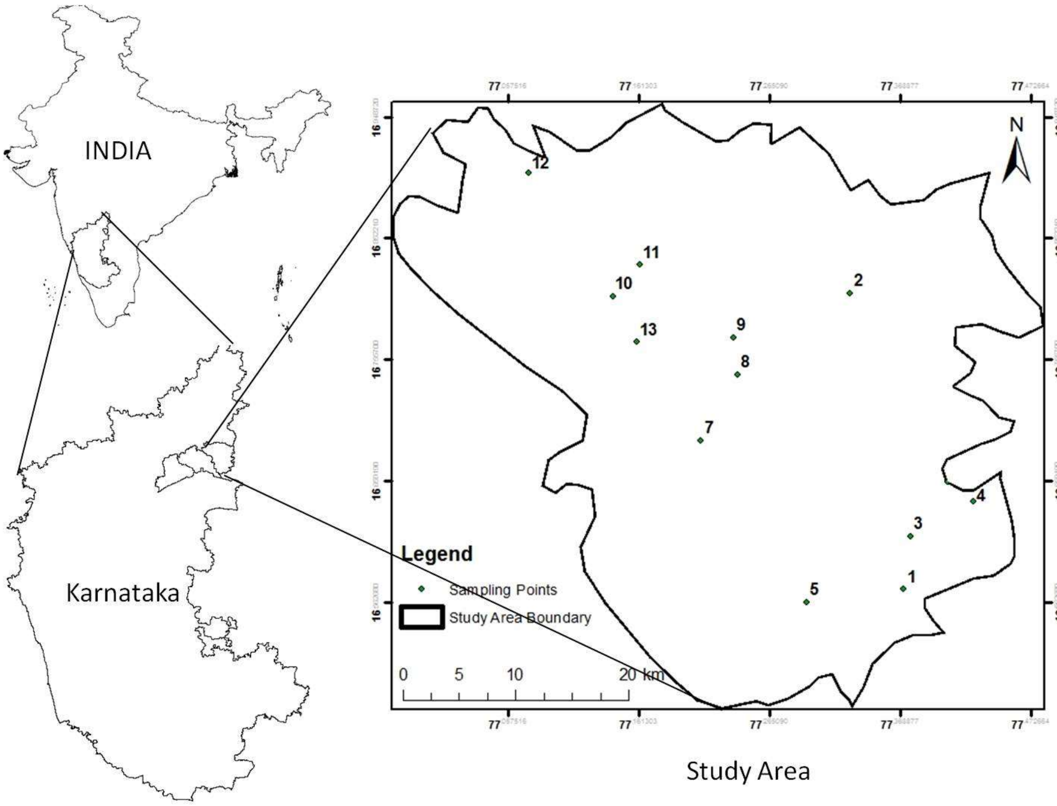
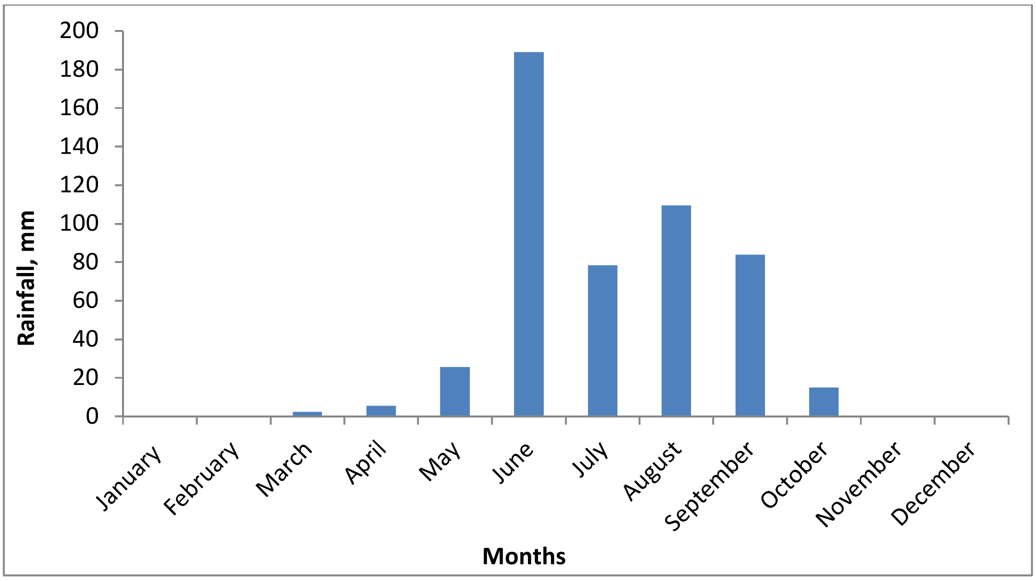
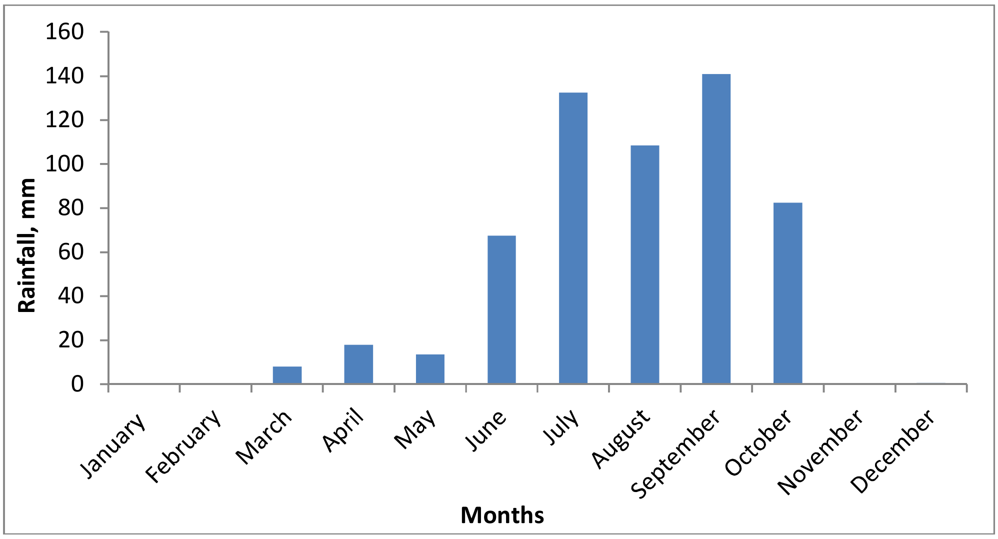


Figure 1: Geographical map of study area



(a)



(b)

Figure 2: Monthly rainfall distribution in study area during 2018 (a) **& 2019** (b)

Table 1: Size of TCT's, volume of earth work incurred and number of farmers benefitted under selected TCT's

Sl.no	Structue Name	As per the Govt scope of work (m^3)	Volume of Excavation (m^3)	Water Storage Created (Ltr)	Beneficiary Farmer
1	Badepalli Tank	48400	62421	62421000	261
2	Chamnalli Tank	13181.82	11	11000	41
3	Jaigram Tank	160000	51888	51888000	149
4	Kandkoor Tank	4009	5350.5	5350500	40
5	Karengi Tank	36131	63912	63912000	144
6	Mailapur Tank	99041	13212	13212000	66
7	Rampur Tank	144000	75852	75852000	155
8	Ramasamudra Tank	80000	50166	50166000	336
9	Wanksambar Tank	55740	50367	50367000	193
10	Yadgir Tank	404000	255252.3	255252300	600
11	Yedhalli Tank	292000	26796	26796000	240
12	Yergol Tank	517120	183939.3	183939300	468
13	Zinkera Tank	88000	110524.5	110524500	488

Results and Discussion

The results of water storage capacity, increase in groundwater levels and increase in crop yield under each selected traditional community tanks are presented & discussed in this section.

Rainfall

The monthly rainfall of study area during 2018 & 2019 is presented in Figure 02 (a & b). Total rainfall of study area was 510 & 572 mm during 2018 & 2019 respectively against average annual rainfall of 836 mm. There was 39 % and 31.57 % less rainfall as compared to average annual rainfall during 2018 & 2019 respectively. However, extreme events during June month in 2018 & September month in 2019 lead to more runoff generation which contributed for increase of water storage capacity of selected community tanks.

Water storage capacity (WSC) of tanks:

Before and after tank rejuvenation, the water storage capacity (MCM) was calculated. All of the desilted anks in the research area had their water storage capacity (WSC) greatly raised. Among all selected tanks, the WSC climbed from 1.45 percent in Zinkara tank (0.02 MCM) to 61.9 percent in Yargola tank (0.13 MCM) (Table 1). Taking into account all decommissioned tanks, the average water storage capacity was raised by 24.80 percent. This rise in WSC results in a significant change in total area irrigated before and after the intervention, ranging from 416 to 1146 ha in *Kharif* and 116 to 340 ha in *Rabi* throughout 2019. During *Kharif and Rabi* 2020, the irrigated command area was raised from 175.88 percent to 193.10 percent. According to the study's findings, tank rejuvenation significantly boosted water storage capacity and irrigated area in the Yadgir district. However, for this study, the area irrigated in the tank command area was compared between two normal monsoon years when the tank was last filled and after desiltation. The rate of increase in water storage capacity was determined by the catchment area's size, rainfall, and cropping pattern (Biswas *et al.,* 2017). Rainfall intensity and duration have a significant impact on runoff created in the catchment region (Vico *et al.,* 2020). However, the Yadgir district's rainfall pattern is unusually scattered and erratic, with only 810 mm of average annual rainfall, which has a direct impact on the water storage capacity of chosen rehabilitated TCTs in the district, and similar results have been recorded by others (Anantha *et al.,* 2021a). Many researchers conducted studies on the effect of tank rejuvenation on the water storage capacity of community tanks across India and reported that rejuvenation of ancient community tanks has a positive impact on the tanks' water storage capacity. According to (Chinnasamy *et al.,* 2015), there was a considerable net increase in water storage and agricultural crop area in Gujarat. Similar findings were obtained for Karnataka by (Brauns *et al.,* 2022) and Tamilnadu by (Van Meter *et al.,* 2016). Well-managed rainwater collection systems by communities or individuals have resulted in considerable improvements in irrigation water supply, the resurrection of the region's agricultural industry, and large gains in farmer incomes and livelihoods (Malik *et al.,* 2014).

Status of groundwater levels (GWL)

Increases in groundwater levels (metres) were estimated for all tanks in the study region before and after tank rejuvenation, and the results are shown in Fig. 3 and Table 2. The findings revealed a considerable increase in groundwater levels in all of the district's restored tanks. After tank rejuvenation in the research region, GWL grew from 0.15 m (Baddepalli) tank to 3.40 m (Yargola) tank during *Rabi* 2019 and 2.10 m (Yadgir, Chamnalli, & Zinkera) tank to 7.05 m (Yargola) tank during *Rabi* 2020. The average GWL increased for all selected tanks from 1.62 m to 3.81 m during the post-monsoon seasons of 2019 and 2020, respectively, compared to 1.31 metres before tank desiltation in *Rabi* 2018. Though GWLs increased during *Rabi* 2019, the percentage gain was insufficient when compared to the desilted tank. The GWL data clearly showed that tank rejuvenation operations had a good influence on groundwater levels in borewells and openwells in selected tank command regions. The difference in groundwater rise between resurrected TCTs was attributed to the amount and availability of stored water in the tanks. No farmer in the command area of these selected tanks had utilised groundwater for irrigation during the *kharif* crop after desilting. Disiltation of TCT's to gather rainwater leads to increased irrigated area and groundwater availability under command area in drought prone regions like Yadgir, and similar findings were experienced by (Van Meter *et al.,* 2016) for Tamil Nadu state. In addition to replenishing groundwater, additional water in the tank caused the water to flow longer distances when the sluice gates opened for irrigation, allowing lower reach farmers to grow (IGG 2020). Across the Indian subcontinent, many researchers observed similar findings. Water levels in wells increased by 2 to 4 feet under the command area of Avalur tank in Tamilnadu (Deivalatha, 2011) and rejuvenated tanks in the Bundelkhand region of Central India reported that, Rejuvenation of the haveli system created an opportunity to harvest surface runoff, which helped to improve groundwater levels in shallow dug wells by 2-5 metres (IGG 2020).

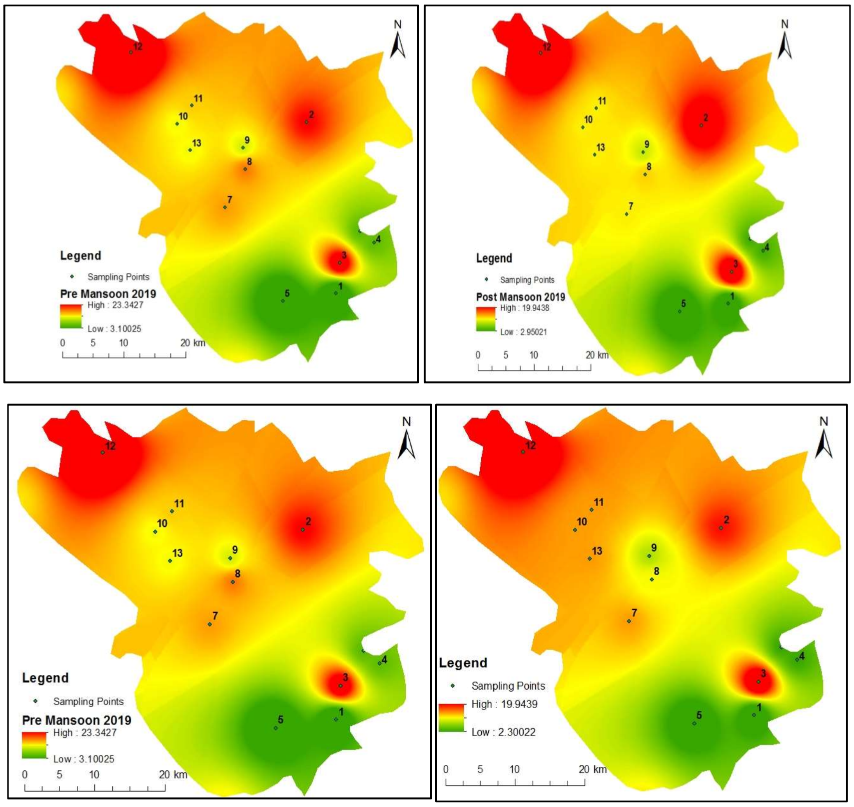


Figure 3: Groundwater levels pre & post monsoon of 2019 and 2020

Table 2: Details of tank area, water storage capacity & benefitted famers under selected traditional community tanks (TCT's) in selected study area

Sl. no	Structure name	Tank Area (ha)	Before Desilting (MCM)	After Desilting (MCM)	Increased WSC (MCM)	% increase WSC
1	Badepalli	121	1.5	1.56	0.06	4.00
2	Chamnalli	12	0.17	0.26	0.09	52.94
3	Jaigram	14	0.11	0.17	0.06	54.55
4	Kandkoor	40	0.56	0.61	0.05	8.93
5	Karengi	10	0.51	0.56	0.05	9.80
6	Mailapur	22	0.33	0.34	0.01	3.03
7	Ramasamudra	36	0.32	0.4	0.08	25.00
8	Rampur	16	0.2	0.31	0.11	55.00
9	Wanksambar	6	0.05	0.06	0.01	20.00
10	Yadgir	130	4.27	4.63	0.36	8.43
11	Yadhalli	20	0.46	0.54	0.08	17.39
12	Yargola	22	0.21	0.34	0.13	61.90
13	Zinkera	101	1.38	1.4	0.02	1.45
	Average	**42.20**	**0.77**	**0.86**	**0.09**	**24.80**

Production and productivity of major crops

The effects of tank disiltation on important crops in the study area before and after tank rejuvenation, as well as the findings are presented in Fig 4-5. Redgram and cotton are the two principal crops grown in Yadgir district during the *Kharif* season; only these crops were studied and assessed. During *Kharif* 2019, Redgram yield increased by 4.13 percent (6.56 q/ha) to 20.57 percent (7.62 q/ha) in Jaigram and Yargola, respectively, with an average of 11.80 percent across all TCTs. Similarly, cotton yields increased by 4.85 percent (7.13 q/ha) to 21.53 percent (7.45 q/ha) in Baddepalli and Yargola with an average of 13.44 percent across all TCTs. The study clearly demonstrated that tank rejuvenation and tank silt application have a positive influence on yield of important crops in selected tank command regions. The application of tank silt and timely supplemental irrigation during the crop growth period increased redgram and cotton yield (Manjula 2017).

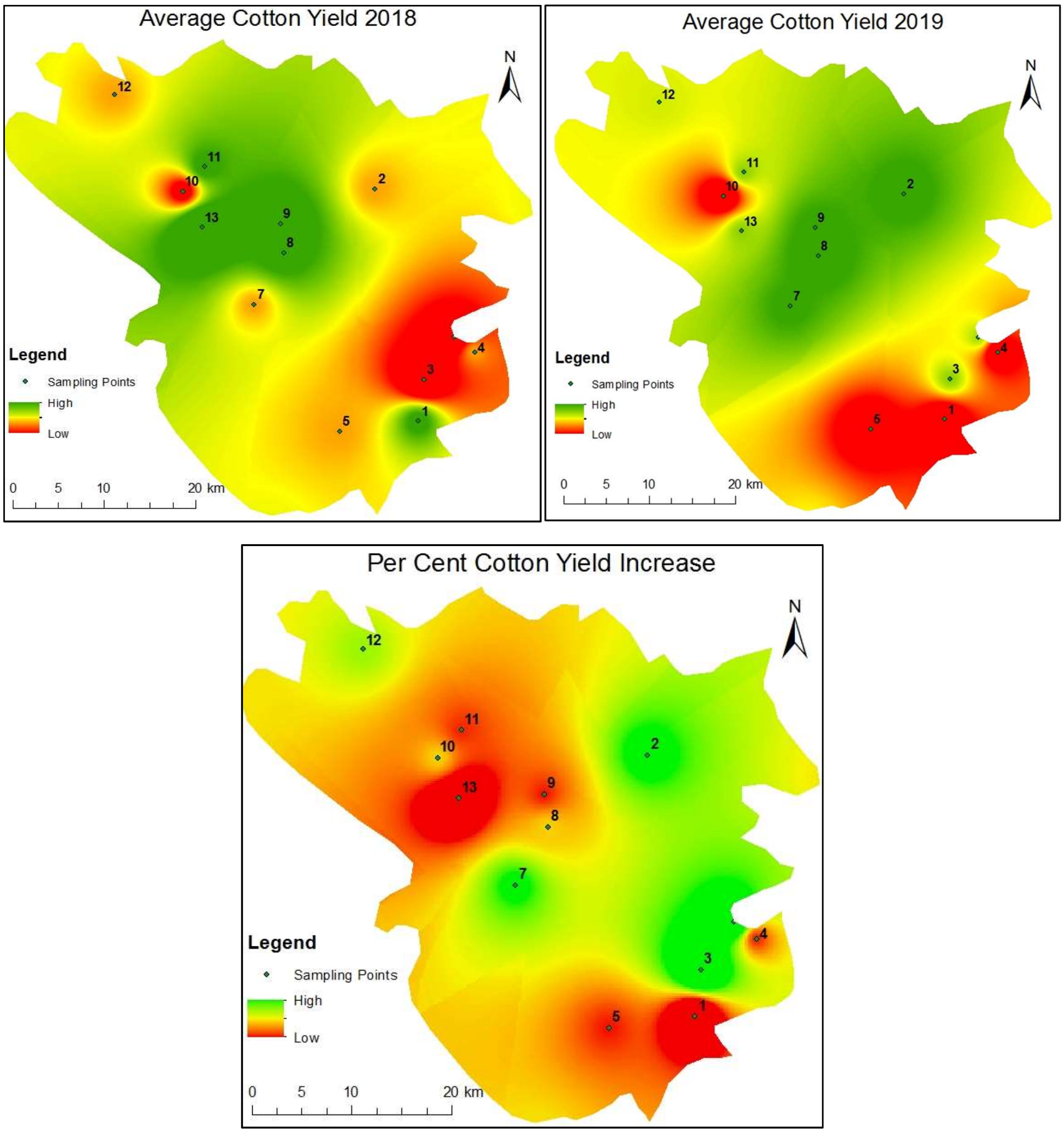


Figure 4: Yield differences in cotton crop after TCT rejuvenation in study area

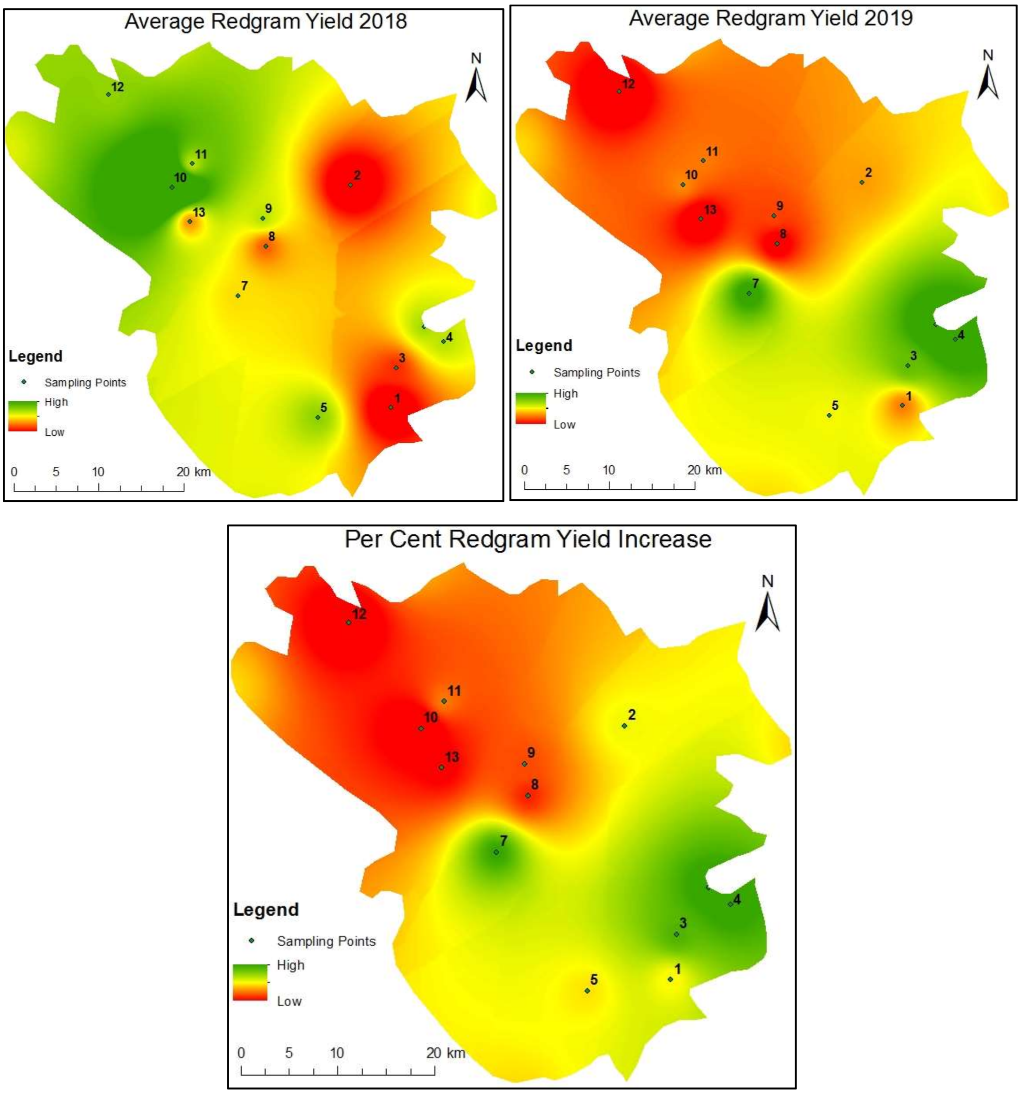


Figure 5: Yield differences in redgram crop after TCT rejuvenation in study area

The combined effect of increased water storage capacity in TCTs and increasing groundwater levels in tube wells within the command area of selected TCTs has made more water accessible for supplemental irrigation, and similar outcomes have been observed by other TCTs (IGG 2020). Supplemental irrigation during crop crucial stages, combined with silt application, increases crop production (Reddy *et al.,* 2020). According to (Srivastava *et al.* 2008), revitalization of community tanks helped to enhance rice yields from 1.92 t ha^{-1} to a range of 2.25 to 3.8 t ha^{-1} in the Keonjhar district of Orissa in eastern India. Many studies concurred that the increased water availability in the community following tank rejuvenation has also permitted irrigation during dry periods, lowering the danger of crop damage during kharif and assisting in crop output increase (Deora and Nanore, 2019).

Conclusion

Because of sustainable agricultural crop production, tank irrigation system management has become the primary intervention for water resource management and rural development. Traditional community tanks irrigation system not only protects and conserves the environment, but also contributes to livelihood security to rural farmers. In the present study, the tank rejunuvation of selected traditional community tanks was helped to improve the livelihood of 50 to 70 % of small and marginal farmers through increasing the crop yield. It is also learnt that, rejunuvated selected TCT's helped to increases the irrigated area and provided water security throughout the crop season and provided opportunities for groundwater recharge, and thus irrigated area extension. The rejunuvated selected TCT's efforts have been shown to alter crop patterns, increase crop yields, and diversify crops, resulting in increased employment and farm income of small & marginal famers of Yadgir district.

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Conflict of interest
The authors declare that they have no conflicts of interest.

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